AOARD REPORT

The Advanced Telecommunications Research Institute (ATR)

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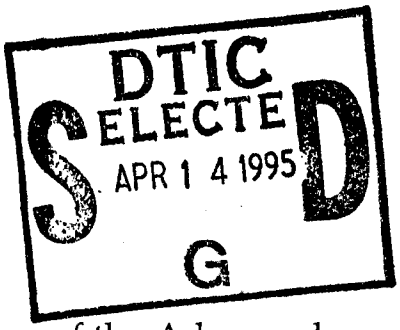

A review of the organization and research program of the Advanced Telecommunications Research Institute (ATR), located in the Kansai Science City near Kyoto, Japan, is presented. This review is based upon information obtained during a 16 May 1994 visit to ATR, and includes a brief description of the current research focus of each of the four active research divisions. Also included is a review of a representative ATR research project, a system concept for teleconferencing with realistic sensations called Virtual Space Teleconferencing.

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Abstract

A review of the organization and research program of the Advanced Telecommunications Research Institute (ATR), located in the Kansai Science City near Kyoto, Japan, is presented. This review is based upon information obtained during a 16 May 1994 visit to ATR, and includes a brief description of the current research focus of each of the four active research divisions. Also included is a review of a representative ATR research project, a system concept for teleconferencing with realistic sensations called Virtual Space Teleconferencing.

1. The Advanced Telecommunications Research Institute (ATR) History and Organization

The Advanced Telecommunications Research Institute International was established in March 1986. It is a Japanese government/industry consortium, with some 140 corporate sponsors and with the Japan Key Technology Center (JKTC) representing the Japanese government. JKTC was created in October 1985 in the aftermath of the privatization of the Japanese national telephone company, Nippon Telegraph and Telephone (NTT). That event was precipitated by the 1985 enactment of Japan's Electronic Communications Business Law and led to private ownership of about 35% of NTT's outstanding stock, with the remaining 65% being held by the Ministry of Finance of the Japanese government. JKTC is operated under co-jurisdiction of the Ministry of Posts and Telecommunications (MPT) and the Ministry of International Trade and Industry (MITI), and is financed from the government's NTT stock dividends. JKTC currently operates some forty five projects, of which the largest is ATR.

ATR's announced guiding principles are: (1) to promote basic and creative telecommunications research, (2) to provide joint research opportunities for industrial, academic and governmental organizations, (3) to contribute to international society and (4) to play a central role in Kansai Science City. Thus, ATR's mission is to advance a mix of telecommunications science and national policy objectives. In particular, ATR is the first and still the dominant scientific research activity located in the Kansai Science City national project, near Kyoto and Osaka.

ATR began operation in March-April, 1986. Initially, it was composed of ATR International, an umbrella company responsible for ATR's overall facilities and administrative operation, and four R&D companies, each operating a research laboratory with an assigned technology area mission. The original four R&D laboratories were the ATR Communication Systems Research Lab, the ATR Interpreting Telephony Research Lab, the ATR Auditory and Visual Perception Research Lab and the ATR Optical and Radio Communications Research Lab. Two other R&D companies, with associated R&D labs called the ATR Human Information Processing Research Lab and the ATR Interpreting Telecommunications Research Lab, were subsequently established in March, 1992 and March, 1993 respectively.

When it is established, each laboratory is assigned an R&D charter which defines its research objectives and a scheduled duration for its research

program. The ATR Auditory and Visual Perception Research Lab and the ATR Interpreting Telephony Research Lab were planned as seven year projects. Their research activities were reported complete in December, 1992 and concluded on schedule on 31 March, 1993. Each is currently engaged only in managing the products (primarily patents) of its completed research program. It should be noted, however, that the two recently established labs' names (ATR Human Information Processing Research Lab and the ATR Interpreting Telecommunications Research Lab) suggest research programs closely related to the programs declared complete. The new labs, and the corresponding new research programs, are essentially continuations of their predecessors.

The current staff at ATR includes about three hundred people, with some seventy administrative staff members and two hundred thirty researchers. The researchers include a mix of permanent, temporarily assigned, and invited members. The largest component of the research staff is the approximately one hundred fifty members employed by some of ATR's corporate sponsors (primarily NTT) or by government labs (e.g.. CRL, the Ministry of Posts and Telecommunications' Communication Research Laboratory) and assigned to ATR labs for typical durations of three years. The permanent ATR research staff currently numbers twenty three. An additional sixty or so research staff members are invited, about fifteen of whom are Japanese and the remaining forty five international. The international invited researchers are predominately American, Canadian or European nationals.

ATR's FY93 (1 Apr 93 - 31 Mar 94) budget was about ¥9B, or about US $88M. The Japanese government, via JKTC, provided about 70% of that amount. The remaining 30% of ATR's FY93 budget was funded by private investment from the 141 Japanese companies, including NTT, which constitute ATR's current corporate sponsor list.

As noted above, one of the guiding principles of ATR is to serve as a nucleus activity for the Kansai Science City. When it was created in 1986, ATR was temporarily housed in the Osaka Business Park. It operated from that location until April 1989, when it became the first scientific research activity to occupy newly constructed facilities in the Kansai Science City. ATR's Kansai facility is an ultramodern four floor building with 24,600 square meters of floor space, housing very well equipped offices, laboratories and specialized test facilities, distributed and centralized computing facilities, conference rooms, libraries and dining/lounge facilities. The centralized computing facility is built up around a Connection Machine (CM-2), and the specialized test facilities include both RF and audio anechoic chambers and electronic device fabrication clean rooms.

ATR researchers publish their work in domestic and international journals, as well as in internal technical reports. During FY93, 542 domestic and 207 international publications were completed. Due in part to the large number of international researchers, a sizable fraction of the internal technical reports are in English, as is most of the work published internationally. However, most domestic publications are in Japanese, though usually an English language abstract is available. Information concerning the availability of ATR technical publications can be obtained at the following address.

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2. The Active ATR Research Laboratories

As noted in Section 1 above, ATR currently includes four active research laboratories. Each is briefly described below in terms of its technical focus.

2.1 The ATR Communication Systems Research Lab

As indicated in Section 1, the ATR Communication Systems Research Lab is one of the four original R&D laboratory components of ATR. It is presently entering its ninth year of operation, and currently is staffed by forty seven active researchers. The scheduled duration of its research program is ten years, however, as noted in the Section 1 discussion of the Interpreting Telephony and Auditory and Visual Perception labs' R&D program completion, these terminations are somewhat artificial. There is every reason to believe that a new laboratory with a closely related R&D program charter will be established.

The ATR Communication Systems Research Lab conducts research in three primary areas, Communication With Realistic Sensations, Secure Communication Systems, and Automatic Generation of Communications Software. The Communication With Realistic Sensations project area is the largest of the three in terms of laboratory resources utilized, and has fostered a widely publicized ATR project called "Virtual Space Teleconferencing". The Virtual Space Teleconferencing project is the subject of Section 3 below. The Secure Communication Systems effort is devoted primarily to very high capacity (2D/3D image) communication systems. The Automatic Generation of Communications Software research is essentially a specification description language (SDL) development project. Its goal is an automated system, usable by novices, which can obtain a complete specification from ambiguous and fragmentary requirements.

Some of the Communication Systems research program, in particular the Virtual Space Teleconferencing project, draws very heavily on visual image generation and processing work conducted in the ATR Human Information Processing Research Lab research program. An apparent consequence is a much closer working relationship between these two labs than appears to exist elsewhere in ATR.

2.2 The ATR Interpreting Telecommunications Research Lab

The ATR Interpreting Telecommunications Research Lab was established in March, 1993, and is thus entering its second year of operation. Its research program is essentially a continuation of the program begun in 1986 by the

ATR Interpreting Telephony Research Lab. It is currently staffed by fifty three active researchers.

The Interpreting Telephony Lab's research program is exclusively devoted to automated speech recognition, synthesis and language translation. A variety of basic speech spectral analysis, speaker adaptive recognition, situational speech analysis, Japanese-English and Japanese-German language translation and human language data base projects are underway to serve as the basic research foundation of the lab's umbrella project, the Advanced Speech Understanding and Rendering System of ATR (ASURA). ASURA is in an intermediate stage of development. Its stated aim is to facilitate efficient communication among people who speak different languages, and it integrates speech recognition, language translation and speech synthesis into a single system architecture. It accepts Japanese speech and generates either an English or German language translation. In January, 1993, ASURA was featured in an international telephony translation experiment, conducted jointly with Carnegie-Melon University in the U. S. and Siemens in Germany.

2.3 The ATR Human Information Processing Research Lab

The ATR Human Information Processing Research Lab was established in March, 1992, and is thus entering its third year of operation. The official title of the research project which constitutes its charter is "Research on the Human Communication Mechanism", and is essentially a continuation of the research program begun by the ATR Auditory and Visual Perception Research Lab. It is currently staffed by seventy three active researchers.

The research program at the Human Information Processing Lab has as its central theme, understanding the basic human audio and visual information processing mechanisms in order to help define the ideal human/machine interface. The program is divided into seven major project areas: Auditory Analysis and Speech Communications, Speech Production and Spoken Language Generation, Speech Signal Processing and Human Interface Technologies, Higher-order Processing of Visual Information, The Study of Human Visual Pattern Generation, Study of Information Integration and Generation, and Mechanisms for Evolution and Emergence of Brain Communication.

2.4 The ATR Optical and Radio Communication Research Lab

As is the case with the Communications Systems Lab, discussed in Section 2.1 above, the ATR Optical and Radio Communication Research Lab is one of the four original R&D laboratory components of ATR and is presently entering the ninth year of its scheduled ten year R&D program. However, again its R&D program niche is likely to be filled by a new laboratory. It is currently is staffed by forty two active researchers.

The Optical and Radio Communication Research Lab is the most hardware focused lab at ATR. Its has several current RF array antenna projects intended for future mobile satellite and personal communications systems, including both conventional and optically controlled microwave array antennas. Another project area, with direct application to high capacity personal communications, is optical/MMW transducers and monolithic integrated circuit configurations for fiber optic links that carry MMW signals. Several

specialized signal processing projects (e.g. adaptive radio interference and multipath cancellation applications) are also currently active.

As a consequence of its component and device emphasis, the Optical and Radio Communication Research Lab is the primary user of ATR's specialized testing facilities (i.e. the RF anechoic chamber and the clean rooms).

3. The Virtual Space Teleconferencing Project

The Virtual Space Teleconferencing System, being developed in the ATR Communication Systems Research Lab, is one of ATR's flagship projects. It is an attempt to provide an interactive virtual reality based teleconferencing system in which conference participants at remote sites communicate with each other in a virtual workspace which permits cooperative manipulation of virtual objects and provides realistic sensations. ATR has recently assembled a preliminary experimental (but real time) hardware realization of the system concept, as briefly described in the following.

In the experimental system, a conference participant is presented with a 3D image of his remote site counterpart's torso, head and face in a synthesized virtual space. The image is presented on a 70 inch stereoscopic display and is viewed via helmet mounted LCD shutter glasses. The 3D image is generated in a workstation at the observer's site from a local data base describing the virtual scene and from a 3D description of the remote site counterpart. The 3D description of the remote site human counterpart is generated from a combination of locally stored 3D information collected in advance (i.e. a 3D wire frame model of the subject, with color information mapped onto the wire frame), and real time motion/facial expression information sensed at the remote site and transmitted via an Ethernet link. The transmitted motion/facial expression information is used to transform the wire frame model. Each site is equipped with a microphone and speaker to permit vocal communication (with suitable time delay for voice/image synchronization). The system also provides for cooperative manipulation of virtual objects by including (at each site) a locally generated 3D image of the virtual object in the synthesized virtual space image. Manipulation of the virtual object is sensed via data gloves worn by each conference participant. No haptic feedback is provided.

The key problem in this virtual space teleconferencing system is the real-time reproduction of 3D human images. As noted above, it is achieved by generating in advance a 3D color model of the human subject for use at the regeneration site, and then translating and distorting the model in accordance with the real time motion information representing the subject's movements. The a priori 3D color model is created from laser stripe data collected by a Cyberware Color 3D digitizer. The collected 3D coordinate data are converted in software into a 3D wire frame model, and then the color information is mapped onto the wire frame.

The remotely located human subject's motion is sensed via helmet mounted magnetic sensors. Three translation and three rotation parameters are sensed and transmitted. The subject's facial expression is sensed by processing a 2D image of his face, collected by a helmet mounted color TV camera. The extracted information consists of 2D tracking data from a set of nine selected points on the subject's face. The selected points are strategically located, based

on a thorough study of facial expression taxonomy, and to simplify the image processing task, the tracked points are highlighted by applying a blue tape marker at each selected location on the subject's face. The resulting tracking information is transmitted, along with the six motion parameters, to the local observer's site for use in transforming the prestored 3D model.

Conceptually, the virtual space teleconferencing system is symmetric. However, the experimental system hardware only provides for collection/transmission of the 3D human motion/facial expression information (and subsequent reproduction of the 3D human image) in one direction. The motion sensor and facial expression processing are performed in workstations (Iris 4D240/VGX and Iris 4D340/VGX respectively) located at the moving subject's (remote) site. The data glove information necessary to provide for cooperative manipulation of virtual objects is also processed in the motion sensor processing workstation. The reconstructed 3D image is generated in a workstation (Iris Crimson, Reality Engine) at the observer's (local) site.

The experimental hardware realization of the virtual space teleconferencing project provides a very interesting experience, and serves as an excellent testbed for system research. However, most observers would probably find the claims about "communicating with realistic sensations" to be a bit overstated. The realism of the virtual space environment is limited by the necessary head gear (LCD shutter glasses, TV camera, motion sensors) and data glove, and especially by the absence of haptic feedback in the virtual object manipulation experience. The project principals claim that work is currently underway to eliminate this paraphernalia, though it is not clear at the moment how. There are currently no reported plans to implement haptic feedback. These criticisms should be taken in context, however. The project is clearly visionary.